Van Allen probes pinpoint driver of speeding electrons

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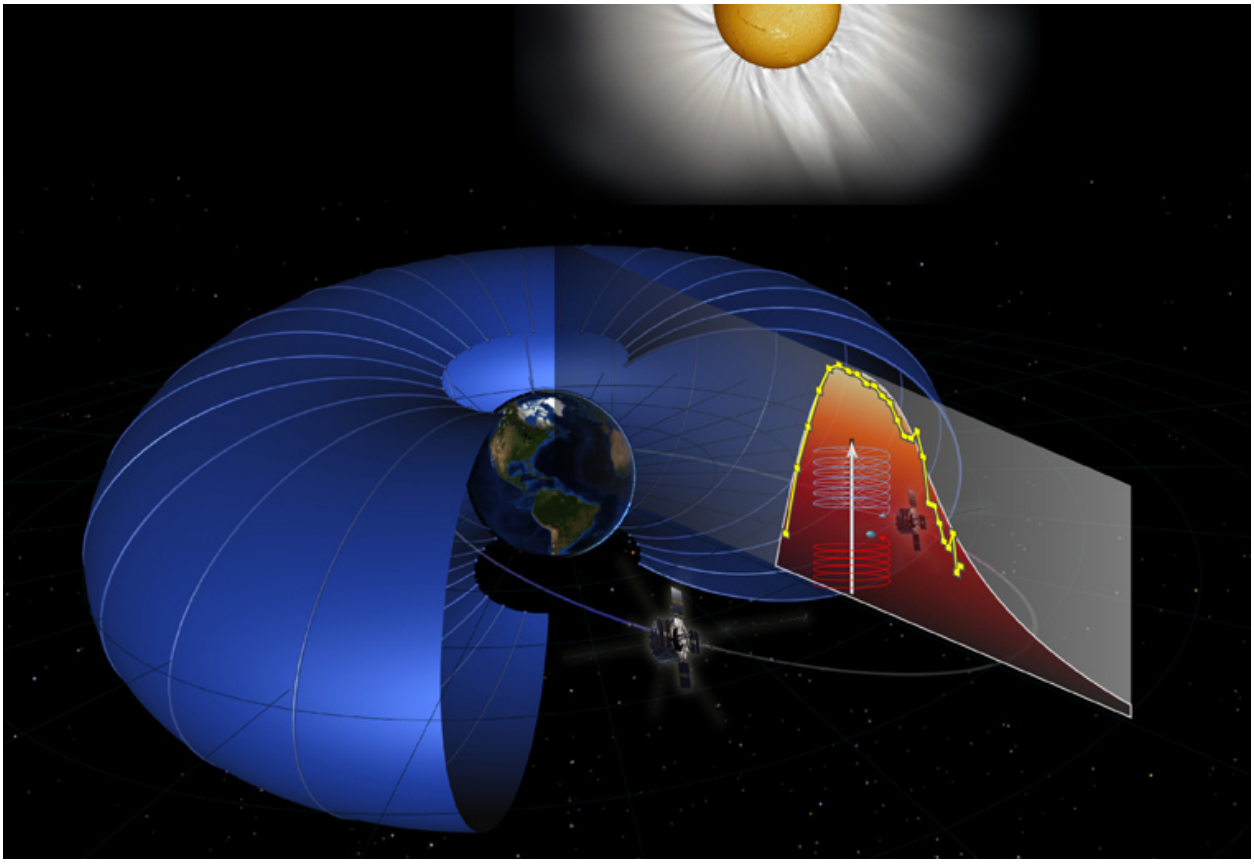

Research team solves decades-old mystery that threatens satellites

LOS ALAMOS, N.M., July 25, 2013 — Researchers believe they have solved a lingering mystery about how electrons within Earth's radiation belt can suddenly become energetic enough to kill orbiting satellites. Thanks to data gathered from an intrepid pair of NASA probes roaming the harsh space environment within the Van Allen radiation belts, scientists have identified an internal electron accelerator operating within the belts.

"For years we thought the Van Allen belts were pretty well behaved and changed slowly," said Geoffrey Reeves of Los Alamos National Laboratory's Intelligence and Space Research Division. "With more measurements, however, we realized how quickly

and unpredictably the radiation belts change, and now we have real evidence that the changes originate from within the belts themselves."

In a paper released today in *Science Express*, Reeves and colleagues from the University of New Hampshire, University of Colorado at Boulder, NASA Goddard Flight Center, Aerospace Corporation, University of California-Los Angeles, and University of Iowa, describe a mechanism by which electrons suddenly accelerate to fantastic speeds within the Van Allen belts— a pair of donut shaped zones of charged particles that surround Earth and occupy the inner region of our planet's Magnetosphere.

Traveling at 99 percent the speed of light, the super-fast electrons are among the speediest particles naturally produced by Earth, and have energies so high that they can penetrate and destroy satellite components. The research paves the way for scientists to possibly predict hazardous space weather and allow satellite operators to potentially prepare for the ravages of sudden space storms.

The radiation belts, named after their discoverer, James Van Allen, are comprised of an outer region of extremely high-energy electrons, with an inner region of energetic protons and electrons. The belts have been studied extensively since the dawn of the Space Age, because the high-energy particles in the outer ring can cripple or disrupt spacecraft. Long-term observation of the belts have hinted that the belts can act as efficient and powerful particle accelerators; recent observations by the Van Allen Probes (formerly known as the Radiation Belt Storm Probes)—a pair of spacecraft launched in August 2012—now seem to confirm this.

On October 9, 2012, while flying through the radiation belts, the Van Allen Probes measured a sudden, nearly thousand-fold increase in the energy of electrons within the outer belt. The rapid increase came on the heels of a period of waning energies the week before. The October 9 event mimicked an observed, but poorly understood event measured in 1997 by another spacecraft. Ever since the 1997 event, scientists have pondered whether the increase in electron energy was the result of forces outside of the belts, a mechanism known as "radial acceleration," or from forces within the belts, known as "local acceleration." Data from the Van Allen Probes seems to put this question to rest.

Because the twin Van Allen Probes follow each other and cut through the belts at different times, researchers were able to see that the October 9 increase originated from within the heart of the belts, indicative of local acceleration. The data also showed that higher electron fluxes did not move from a region outside of the belts slowly toward our planet, a detail corroborated by other geosynchronous satellites located outside of the belts.

"In the October 9, 2012, event, all of the acceleration took place in about 12 hours," said Reeves, a space physicist and principal author of the *Science* paper. "With previous measurement, a satellite might have only been able to fly through such an event once and not get a chance to witness the changes actually happening."

The researchers are now trying to understand exactly how the acceleration took place. Right now, the team believes that electromagnetic radio waves somehow excite the electrons into a higher-energy state, much like a microwave oven excites and heats water molecules. Members of the team are looking hard at waves known as "Chorus Waves" that are often observed in the region of the belts where the local acceleration was strongest. Chorus Waves are a type of electromagnetic radio wave

with frequencies within the range of human hearing. Chorus Waves provide a haunting cacophony like a flock of extraterrestrial birds.

“We don’t know whether it is Chorus Waves or some other type of electromagnetic wave that’s behind the electron acceleration we are seeing,” said Reeves, “but the Van Allen Probes are also equipped with instruments that should help us figure that out as well. Each of these discoveries take us a step closer to the goal of forecasting these extreme space weather events and making space safer for satellites.”

Related Audio

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The sound file contains sounds of Chorus Waves captured by researchers at the University of Iowa. Chorus Waves are often observed in regions of Earth's Van Allen radiation belts where electrons are sometimes accelerated to energies thousands of times higher than their normal energy. Using data from NASA's Van Allen Probes, researchers are finding evidence that the Chorus Waves may be energizing the electrons, which can damage satellites. (sound file courtesy of the University of Iowa)